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Experimental insights on crystal chemistry of high-Ti garnets from garnet-melt partitioning of rare-earth and high-field-strength elements

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Abstract

High-temperature experiments were performed from 3.0 to 7.0 GPa to investigate the effect of composition on near-liquidus garnet-melt trace-element partition coefficients (*D*-values) in a Ti- and Fe-rich lunar bulk composition. Starting compositions were doped with Sc, Sr, Y, Zr, Ba, Nd, Sm, Dy, Yb, Hf, and Th. *D*-values were measured by ion-microprobe analysis. The lattice strain model of Blundy and Wood (1994) was applied to measured *D*-values, and then compared with the predictive garnet-melt trace-element partitioning model of van Westrenen et al. (2001b). Although the lattice-strain model describes our data adequately, there is a substantial mismatch between the prediction of the van Westrenen et al. (2001b) model and the actual measured *D*-values. We suggest crystal-chemical effects associated with the high Ti content of our experimental garnets may be responsible for this mismatch. Titanium alone does not appear to control partitioning; we infer that Fe^{2+} and/or Mg^{2+} are required to partition into octahedral coordination on the Y-site, which may further necessitate Si^{4+} to also partition on the Y-site for charge balance. This combination of effects influences trace-element partitioning in the garnet. Observed changes in *D*-values correlate with the integration of Ti on the Y-site in a majorite-like exchange, yet our garnets incorporate little or no majorite. Garnets grown have some of the lowest apparent Young's modulus values (274–528 GPa) yet documented for the garnet X-site indicating higher compressiblities than previously inferred.

Keywords: Experimental petrology, high-pressure experiments, trace elements and REE, garnet-melt partitioning, major and minor elements, titanium, crystal chemistry